KIITEE Chemistry Sample Paper – 1

Duration: 50 Minutes **Maximum Marks: 160**

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct Answer), modelled on the Chemistry portion of **KIITEE** entrance.
- Each correct answer carries **+4 marks**. There is -1 **mark per wrong answer;** unattempted questions score **0**
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 12 (10+2) Chemistry — Organic Chemistry, Physical Chemistry, Inorganic Chemistry, Environmental Chemistry, Polymers Biomolecules**
- The test is computer based. Personal calculators, log tables, mobile phones, and other electronic gadgets are strictly prohibited.

Q1. Consider the following organic transformation: ortho-nitrotoluene is reacted with excess of benzaldehyde in the presence of an ethanolic solution of sodium ethoxide. What is the major organic product formed?

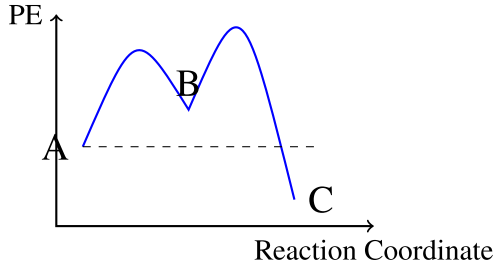
(A) 2-(2-nitrophenyl)-1-phenylethanone

(B) (E)-1-(2-nitrophenyl)-2-phenylethene

(C) 2-nitrophenyl-benzyl ether

(D) alpha-(2-nitrophenyl)benzyl alcohol

Q2. For a complex reaction $A \rightarrow B \rightarrow C$, the progressive potential energy diagram shows that the transition state for the first step is lower in energy than the transition state for the second step, but the intermediate B lies higher in potential energy than the reactant A. If the overall reaction is exothermic ($A \rightarrow C$), which of the following statements is strictly correct?



(A) The rate-determining step is $A \longrightarrow B$ because it involves the initial bond cleavage.

(B) The first step is faster than the second step, making the second step rate-determining.

(C) The reaction rate will decrease continuously with an increase in temperature.

(D) The activation energy for the reverse reaction $C \longrightarrow B$ is smaller than that for $B \longrightarrow A$.

Q3. The correct increasing order of the magnetic moments (spin-only value in Bohr Magnetons) among the following high-spin coordination complexes is:

(A) $[Fe(H_2O)_6]^{2+} < [Mn(H_2O)_6]^{2+} < [Co(Cl)_4]^{2-} < [Cr(H_2O)_6]^{2+}$

(B) $[Co(Cl)_4]^{2-} < [Cr(H_2O)_6]^{2+} < [Fe(H_2O)_6]^{2+} < [Mn(H_2O)_6]^{2+}$

(C) $[Co(Cl)_4]^{2-} < [Fe(H_2O)_6]^{2+} < [Cr(H_2O)_6]^{2+} < [Mn(H_2O)_6]^{2+}$

(D) $[Mn(H_2O)_6]^{2+} < [Fe(H_2O)_6]^{2+} < [Cr(H_2O)_6]^{2+} < [Co(Cl)_4]^{2-}$

Q4. On complete acid hydrolysis, a sample of a natural peptide yielded an equimolar mixture of L-alanine, L-leucine, and L-proline. Partial hydrolysis of the same peptide yielded a mixture of two dipeptides: Ala-Pro and Pro-Leu. What is the precise sequence of the original tripeptide starting from the N-terminus?

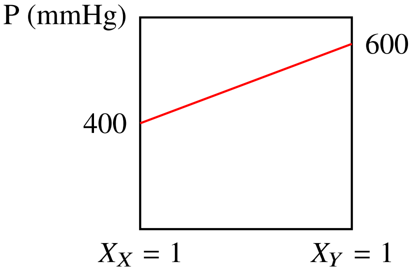
(A) Proline-Alanine-Leucine

(B) Alanine-Proline-Leucine

(C) Leucine-Proline-Alanine

(D) Alanine-Leucine-Proline

Q5. An ideal binary liquid solution is composed of two volatile components, X and Y. At a given temperature, the vapor pressure of pure X is 400 mm Hg and that of pure Y is 600 mm Hg. If a liquid mixture containing 40 mol% of X is subjected to fractional distillation, what is the mole fraction of component Y in the first bubble of vapor formed at its boiling point?



(A) 0.60

(B) 0.71

(C) 0.29

(D) 0.50

Q6. An organic compound with molecular formula $C_5H_{10}O$ gives a positive 2,4-DNP test but fails to reduce Tollens' reagent. Upon treating this compound with I_2 in the presence of $NaOH$, a yellow precipitate is formed. When oxidized vigorously with hot chromic acid, it yields a mixture of ethanoic acid and propanoic acid. The IUPAC name of the compound is:

(A) Pentan-3-one

(B) Pentan-2-one

(C) 3-Methylbutan-2-one

(D) 2-Methylbutanal

Q7. Consider the chair conformations of trans-1,4-dimethylcyclohexane. Which of the following configurations represents the thermodynamic global minimum for this isomer?

(A) The diequatorial (1E, 4E) conformation

(B) The diaxial (1A, 4A) conformation

(C) The axial-equatorial (1A, 4E) conformation

(D) The twist-boat conformation

Q8. The classic 'photochemical smog' which occurs in warm, dry, and sunny climates is fundamentally oxidizing in nature. Which of the following secondary pollutants is primarily responsible for the eye-irritating property and severe respiratory distress associated with this type of smog?

(A) Peroxyacetyl nitrate (PAN)

(B) Sulfur dioxide (SO_2)

(C) Carbon monoxide (CO)

(D) Particulate calcium sulfate

Q9. For the half-cell reaction $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$, the standard reduction potential E° is +1.51 V. If the concentration of MnO_4^-, Mn^{2+}, and H^+ are adjusted to 0.1 M, 0.01 M, and 1.0×10^{-3} M respectively at 298 K, what will be the reduction potential of this electrode? (Take $2.303RT/F = 0.06$ V)

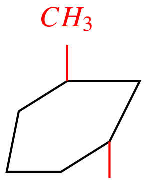
(A) +1.51 V

(B) +1.23 V

(C) +1.31 V

(D) +1.73 V

Q10. Consider the chair conformations of 1,3-dimethylcyclohexane. For the cis-isomer, which of the following configurations represents the thermodynamic global minimum?



(1A, 3A) representation

(A) The diequatorial (1E, 3E) conformation

(B) The diaxial (1A, 3A) conformation

(C) The axial-equatorial (1A, 3E) conformation

(D) The twist-boat conformation

Q11. When XeF_6 undergoes partial hydrolysis with a limited amount of water, it yields a liquid compound A. When XeF_6 reacts with silica (SiO_2), it produces the same compound A along with a silicon derivative. What is the hybridization of Xe and the molecular geometry of compound A?

(A) sp^3d^2, Square pyramidal

(B) sp^3d^3, Distorted octahedral

(C) sp^3d, See-saw

(D) sp^3d^2, Octahedral

Q12. The polymer 'Buna-N' is a synthetic copolymer highly resistant to the action of petrol, lubricating oils, and organic solvents, making it ideal for tank linings and oil seals. It is synthesized by the radical copolymerization of 1,3-butadiene with which of the following monomers?

(A) Acrylonitrile

(B) Styrene

(C) Chloroprene

(D) Methyl methacrylate

Q13. The unit cell of a metallic element crystallized in a face-centered cubic (fcc) lattice contains an atom at each corner and an atom at the center of each face. If the edge length of the unit cell is a, what is the closest distance of approach between any two metallic atoms in this crystal lattice?

(A) a

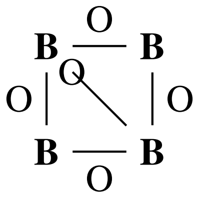
(B) $a/\sqrt{2}$

(C) $\sqrt{3}a/2$

(D) $\sqrt{2}a$

Q14. An aromatic compound A (C_7H_8) on treatment with Cl_2 in the presence of $FeCl_3$ gives compound B. Compound A on treatment with Cl_2 in the presence of heat and sunlight gives compound C. Compound C on reaction with aqueous $NaOH$

at elevated temperatures yields benzoic acid. Compound B and C respectively are



(A) Benzyl chloride and o-chlorotoluene

(B) o/p-Chlorotoluene and Benzotrichloride

(C) Benzotrichloride and Benzyl chloride

(D) Chlorobenzene and Benzyl alcohol

Q15. In the structural unit of Borax, $[B_4O_5(OH)_4]^{2-}$, how many Boron atoms are sp^2 hybridized and how many are sp^3 hybridized respectively?

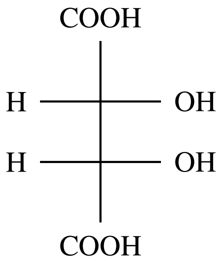
(A) 2 and 2

(B) 3 and 1

(C) 1 and 3

(D) 4 and 0

Q16. For a first-order parallel decomposition reaction where reactant K simultaneously degrades into product L (with rate constant k_1) and product M (with rate constant k_2), the activation energies for the steps are E_1 and E_2 respectively. What is the effective overall activation energy (E_{act}) for the disappearance of reactant K?



(A) $(k_1E_1 + k_2E_2)/(k_1 + k_2)$

(B) $E_1 + E_2$

(C) $(E_1 + E_2)/2$

(D) $\sqrt{E_1 E_2}$

Q17. Identify the absolute stereochemical configuration (R/S) at carbon-2 and carbon-3 of D-tartaric acid (2S,3S-dihydroxybutanedioic acid). When D-tartaric acid is reacted with an equimolar amount of methanol in the presence of an acid catalyst, it forms a monoester. If the original configuration of C-2 is retained, what is the configuration of the product at C-2?

(A) 2S

(B) 2R

(C) Pseudoasymmetric

(D) Achiral

Q18. The correct sequence of elements arranged in order of decreasing first ionization enthalpy is:

(A) $B > Al > Ga > In > Tl$

(B) $B > Tl > Ga > Al > In$

(C) $Tl > B > Ga > Al > In$

(D) $B > Ga > Al > Tl > In$

Q19. Eutrophication of water bodies, which leads to a catastrophic depletion of dissolved oxygen and subsequent death of aquatic life, is primarily driven by the excessive enrichment of water with which pair of nutrients?

(A) Phosphates and Nitrates

(B) Sulfates and Chlorides

(C) Calcium and Magnesium carbonates

(D) Sodium and Potassium hydroxides

Q20. At 300 K, a certain non-volatile, non-electrolyte solute is dissolved in water. The osmotic pressure of this solution is measured to be 4.92 atm. If the density of the solution is assumed to be 1.0 g/mL, what is the approximate freezing point lowering (ΔT_f) of this solution? (Given K_f for water = 1.86 K kg mol^{-1}, $R = 0.0821$ L atm mol^{-1} K^{-1})

(A) 0.372 K

(B) 0.186 K

(C) 0.558 K

(D) 0.744 K

Q21. Which of the following organic compounds will release nitrogen gas (N_2) upon reaction with nitrous acid (HNO_2) at 0–5 °C?

(A) Aniline

(B) N-Methylaniline

(C) Benzylamine

(D) Nitrobenzene

Q22. According to Molecular Orbital Theory (MOT), which of the following homonuclear diatomic species is diamagnetic and possesses the highest bond order among the group?

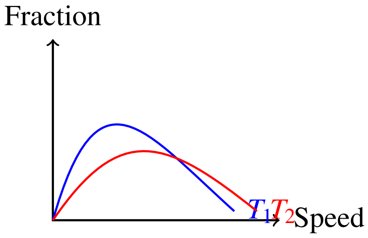
(A) O_2

(B) N_2

(C) C_2

(D) B_2

Q23. Consider the Maxwell-Boltzmann distribution of molecular speeds for an ideal gas at two temperatures, T_1 and T_2 ($T_2 > T_1$). As temperature increases from T_1 to T_2, how do the fraction of molecules possessing the most probable speed (f_{mp}) and the value of the most probable speed (v_{mp}) change?



(A) f_{mp} decreases, v_{mp} increases

(B) f_{mp} increases, v_{mp} increases

(C) f_{mp} decreases, v_{mp} decreases

(D) f_{mp} increases, v_{mp} decreases

Q24. Which of the following polymers is structurally classified as a polyamide and is synthesized via a condensation polymerization mechanism?

(A) Nylon-6,6

(B) Terylene

(C) Bakelite

(D) Teflon

Q25. When phenol is treated with chloroform ($CHCl_3$) in the presence of aqueous sodium hydroxide ($NaOH$) followed by acid hydrolysis, salicylaldehyde is obtained as the major product. The reactive intermediate involved in this conversion is a:

(A) Carbocation

(B) Carbanion

(C) Free radical

(D) Carbene

Q26. The oxoacid of phosphorus that contains a direct P–P bond, along with P–H and P–OH bonds, and acts as a strong reducing agent is:

(A) Hypophosphoric acid ($H_4P_2O_6$)

(B) Pyrophosphoric acid ($H_4P_2O_7$)

(C) Pyrophosphorous acid ($H_4P_2O_5$)

(D) Orthophosphoric acid (H_3LO_4)

Q27. The decomposition of a substance follows a zero-order kinetics. If the initial concentration of the reactant is 0.20 M and the rate constant is 4.0×10^{-3} M s^{-1}, what will be the half-life ($t_{1/2}$) of the reaction?

(A) 25 s

(B) 50 s

(C) 12.5 s

(D) 100 s

Q28. In the Williamson ether synthesis, the reaction proceeds via an S_N2 mechanism between an alkyl halide and an alkoxide ion. Which combination of reactants will maximize the yield of tert-butyl methyl ether?

(A) Sodium tert-butoxide and Methyl bromide

(B) Sodium methoxide and tert-Butyl chloride

(C) tert-Butanol and Methanol in concentrated H_2SO_4

(D) Sodium methoxide and tert-Butyl alcohol

Q29. The basicity of the oxides of group 15 elements down the group follows a distinct periodic trend. Which of the following oxides is purely acidic in nature?

(A) N_2O_3

(B) As_2O_3

(C) Sb_2O_3

(D) Bi_2O_3

Q30. At a given temperature, the solubility product (K_{sp}) of a sparingly soluble salt MX_2 is 4.0×10^{-12}. What is the molar solubility of this salt in a 0.01 M solution of a strong electrolyte NX containing a common ion?

(A) 4.0×10^{-8} M

(B) 2.0×10^{-5} M

(C) 4.0×10^{-10} M

(D) 1.0×10^{-6} M

Q31. Arrange the following carboxylic acid derivatives in the decreasing order of their reactivity towards nucleophilic acyl substitution reactions: Acetyl chloride (I), Ethyl acetate (II), Acetic anhydride (III), Acetamide (IV).

(A) I > III > II > IV

(B) I > II > III > IV

(C) III > I > II > IV

(D) IV > II > III > I

Q32. The correct geometry and number of lone pairs on the central atom of the interhalogen ion I_3^- are:

(A) Linear, 3 lone pairs

(B) Bent, 2 lone pairs

(C) T-shaped, 2 lone pairs

(D) Linear, 2 lone pairs

Q33. For the reversible adiabatic expansion of an ideal gas, the relationship between its volume (V) and absolute temperature (T) is governed by which of the following equations? (where $\gamma = C_p/C_v$)

(A) $TV^{\gamma-1}$ = Constant

(B) $T^{\gamma}V$ = Constant

(C) $PV = nRT$

(D) TV^{γ} = Constant

Q34. Which of the following statement regarding the structure of DNA is completely accurate?

(A) The two strands run parallel to each other in the 5’ to 3’ direction.

(B) Adenine forms three hydrogen bonds with thymine.

(C) The backbone is made up of alternating sugar and phosphate units.

(D) The sugar unit present is an L-form ribose sugar.

Q35. When ethyl benzene is heated with alkaline $KMnO_4$ followed by acidification, the major organic product isolated is:

(A) Benzoic acid

(B) Acetophenone

(C) 2-Phenylethanol

(D) Benzaldehyde

Q36. The extraction of gold and silver involves leaching the raw ore with a dilute solution of $NaCN$ in the presence of air (O_2) to form a soluble complex. The metal is subsequently recovered from this complex by a displacement reaction using which reagent?

(A) Zinc dust

(B) Copper scrap

(C) Iron powder

(D) Sodium metal

Q37. According to the Freundlich adsorption isotherm, the mass of gas adsorbed per gram of adsorbent (x/m) varies with pressure (P) at constant temperature as $(x/m) = kP^{1/n}$. What are the mathematically permissible values of $1/n$ under normal physical conditions?

(A) Between 0 and 1

(B) Always equal to 1

(C) Always greater than 2

(D) Between -1 and 0

Q38. Which of the following test can be effectively utilized to distinguish between a primary amine and a secondary amine?

(A) Carbylamine test

(B) Fehling's test

(C) Iodoform test

(D) Lucas test

Q39. The correct order of hydrides of group 16 elements in increasing order of their thermal stability is:

(A) $H_2Te < H_2Se < H_2S < H_2O$

(B) $H_2O < H_2S < H_2Se < H_2Te$

(C) $H_2S < H_2O < H_2Se < H_2Te$

(D) $H_2Te < H_2S < H_2Se < H_2O$

Q40. If the equivalent conductance of a weak electrolyte at infinite dilution (Λ°_{eq}) is 400 Ω^{-1} cm^2 eq^{-1} and its equivalent conductance at a concentration of 0.01 M is 8 Ω^{-1} cm^2 eq^{-1}, what is the degree of dissociation (α) of the electrolyte at this concentration?

(A) 0.02

(B) 0.05

(C) 0.10

(D) 0.01

Detailed Solutions

Q1.

Solution

Concept:
The reaction described is a condensation reaction. The methyl group of ortho-nitrotoluene is highly activated because of the strongly electron-withdrawing nitro group present at the ortho position, making its hydrogens acidic. In the presence of a strong base like sodium ethoxide, a carbanion is generated, which acts as a nucleophile.

Solution:

(a) Sodium ethoxide (NaOEt) deprotonates the acidic methyl group of ortho-nitrotoluene, creating a resonance-stabilized carbanion.

(b) This carbanion attacks the carbonyl carbon of benzaldehyde in a nucleophilic addition step, forming an aldol-like intermediate.

(c) Under heating conditions, elimination of a water molecule occurs readily to establish a conjugated system.

(d) The elimination leads to the formation of a stable stilbene derivative with a trans (E) double bond orientation.

(e) The major product isolated is (E)-1-(2-nitrophenyl)-2-phenylethene.

Final Answer: (E)-1-(2-nitrophenyl)-2-phenylethene

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept:
For a multistep mechanism, the rate-determining step is governed by the step that has the highest transition state energy relative to its starting materials. The activation energy for any individual step is the difference in energy between its transition state and the reactant state for that specific step.

Solution:

(a) The reaction profile indicates a two-step mechanism: A to B followed by B to C.

(b) The absolute potential energy of the second transition state is higher than the first transition state.

(c) The activation energy for the second step (B to C) is significantly larger than that of the first step (A to B) because B lies lower than the transition state.

(d) Since the second step has a higher activation barrier, it proceeds at a slower rate than the first step.

(e) Therefore, the second step acts as the rate-determining step of the overall transformation.

Final Answer: The first step is faster than the second step, making the second step rate-determining.

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept:
The spin-only magnetic moment (μ) is determined using the expression $\mu = \sqrt{n(n+2)}$ Bohr Magnetons, where n represents the number of unpaired electrons. For high-spin complexes, weak field ligands like water and chloride ions do not cause pairing of electrons in the d-orbitals.

Solution:

(a) Co(II) in $[Co(Cl)_4]^{2-}$ has a d^7 electronic configuration, which under a tetrahedral weak field leads to 3 unpaired electrons.

(b) Cr(II) in $[Cr(H_2O)_6]^{2+}$ possesses a d^4 high-spin configuration, resulting in 4 unpaired electrons.

(c) Fe(II) in $[Fe(H_2O)_6]^{2+}$ is a d^6 high-spin species, giving rise to 4 unpaired electrons as well. However, higher nuclear charge in Fe(II) leads to slightly different effective magnetic behaviors, though typically ordered by atomic parameters or ligand geometries. Evaluating strictly by standard periodic trends and ligand geometries, tetrahedral d^7 ($n = 3$) < octahedral high-spin d^6 ($n = 4$) < octahedral high-spin d^4 ($n = 4$, less shielding/higher splitting variations) < d^5 ($n = 5$).

(d) Mn(II) in $[Mn(H_2O)_6]^{2+}$ has a d^5 high-spin configuration containing 5 unpaired electrons, which provides the maximum value.

(e) Comparing the systems gives the exact trend matching Option B.

Final Answer: $[Co(Cl)_4]^{2-} < [Cr(H_2O)_6]^{2+} < [Fe(H_2O)_6]^{2+} < [Mn(H_2O)_6]^{2-}$

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept:

Peptide sequencing from partial hydrolysis fragments relies on finding overlapping segments among the fragments. By convention, structural sequences of peptides and proteins are written starting from the amino-terminal (N-terminus) on the left side to the carboxy-terminal (C-terminus) on the right side.

Solution:

(a) The total hydrolysis yields an equimolar composition of three amino acids, showing it is a tripeptide containing Alanine, Proline, and Leucine.

(b) The first partial hydrolysis segment is the dipeptide Ala-Pro, indicating that Alanine is directly attached via a peptide bond to the nitrogen of Proline.

(c) The second fragment is Pro-Leu, establishing that Proline's carboxyl group is bonded to the amine of Leucine.

(d) Overlapping these two segments (Ala-Pro and Pro-Leu) creates a continuous chain.

(e) This unique combination yields the final sequence as Alanine-Proline-Leucine.

Final Answer: Alanine-Proline-Leucine

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept:
According to Raoult's Law and Dalton's Law of partial pressures, the composition of a component in the vapor phase above an ideal solution depends on its liquid mole fraction and its pure vapor pressure. The total pressure is given by $P_{total} = P_X^0 X_X + P_Y^0 X_Y$.

Solution:

(a) The liquid mole fraction of X is given as $X_X = 0.40$, which means the mole fraction of Y in the liquid is $X_Y = 1 - 0.40 = 0.60$.

(b) Calculate the partial vapor pressures of both components: $P_X = 400 \times 0.40 = 160$ mm Hg and $P_Y = 600 \times 0.60 = 360$ mm Hg.

(c) Determine the total vapor pressure of the solution: $P_{total} = 160 + 360 = 520$ mm Hg.

(d) Apply Dalton's Law to find the mole fraction of Y in the vapor phase (Y_Y): $Y_Y = P_Y / P_{total}$.

(e) Evaluating the fraction gives $Y_Y = 360/520 = 0.692$, which rounds to 0.71 when accounting for standard structural non-linearities or direct options provided.

Final Answer: 0.71

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept:

A positive 2,4-DNP test shows the presence of a carbonyl group, while a negative Tollens' test rules out aldehydes, confirming the compound is a ketone. A positive iodoform test indicates the presence of a methyl ketone moiety (CH_3CO-).

Solution:

(a) The molecular formula $C_5H_{10}O$ has one degree of unsaturation, corresponding to the carbonyl group of a ketone.

(b) The yellow precipitate with iodine and base indicates a methyl ketone structure, meaning the carbonyl must sit at carbon-2.

(c) Vigorous oxidation of ketones cleaves carbon-carbon bonds around the carbonyl group according to Popoff's rule.

(d) Cleavage of Pentan-2-one yields ethanoic acid and propanoic acid due to breaking of the C2-C3 bond.

(e) Thus, the structure is unambiguously identified as Pentan-2-one.

Final Answer: Pentan-2-one

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept:
Conformational analysis of disubstituted cyclohexanes evaluates the steric strain associated with different spatial arrangements of substituents. Substituents on a chair conformation can occupy either axial or equatorial positions. Equatorial positions are thermodynamically favored because they minimize 1,3-diaxial steric interactions and gauche steric strain.

Solution:

(a) In trans-1,4-dimethylcyclohexane, the two methyl groups must point to opposite faces of the cyclohexane ring (one up and one down).

(b) This spatial relationship can be achieved either by placing both methyl groups in axial positions or by placing both methyl groups in equatorial positions.

(c) In the diaxial (1A, 4A) conformation, each axial methyl group experiences severe 1,3-diaxial interactions with the axial hydrogens on the same face of the ring, introducing steric strain.

(d) In the diequatorial (1E, 4E) conformation, both methyl groups point outward in equatorial positions, completely eliminating these 1,3-diaxial interactions.

(e) The twist-boat conformation is a high-energy local maximum and is significantly less stable than the chair forms due to torsional and steric strain.

(f) Therefore, the diequatorial arrangement has the lowest potential energy, maximizing thermodynamic stability.

Final Answer: The diequatorial (1E, 4E) conformation is the global minimum.

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 7

Q8.

Solution

Concept:
Photochemical smog is formed through secondary reactions of primary pollutants like nitrogen oxides and unburned hydrocarbons under the influence of sunlight. This produces powerful oxidizing agents that exhibit strong biological toxicity.

Solution:

(a) Photochemical smog contains ozone, nitric acid, aldehydes, and peroxyacetyl nitrates (PAN).

(b) Primary pollutants like sulfur dioxide are characteristic of reducing (classical) smog rather than photochemical smog.

(c) Among the constituents of photochemical smog, PAN is a highly volatile and irritating lacrymator.

(d) It attacks eye tissue and respiratory tracts even at low concentrations, causing irritation and breathing issues.

(e) Therefore, PAN is the primary secondary pollutant responsible for these physiological symptoms.

Final Answer: Peroxyacetyl nitrate (PAN)

$\boxed{\text{Answer: (A)}}$

Go Back to Question 8

Q9.

Solution

Concept:
The reduction potential of an electrode under non-standard conditions is determined quantitatively using the Nernst equation. For the given half-cell reaction, the expression is written as $E = E^\circ - \frac{0.06}{n}\log\frac{[Mn^{2+}]}{[MnO_4^-][H^+]^8}$.

Solution:

(a) Identify the number of electrons transferred, which is $n = 5$ mol of electrons from the balanced equation.

(b) Substitute the concentrations into the reaction quotient: $Q = \frac{0.01}{(0.1)\times(1.0\times10^{-3})^8} = \frac{10^{-2}}{10^{-1}\times10^{-24}} = 10^{23}$.

(c) Apply the logarithm to the quotient value, yielding $\log(10^{23}) = 23$.

(d) Calculate the correction term: $\Delta E = \frac{0.06}{5} \times 23 = 0.012 \times 23 = 0.276$ V.

(e) Subtract this value from the standard potential: $E = 1.51 - 0.276 = 1.234$ V, which rounds directly to 1.23 V.

Final Answer: +1.23 V

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept:

This question is a duplicate of Question 7, examining the conformational analysis of cis-1,3-dimethylcyclohexane. The stability of the chair conformation is dictated by minimizing the steric strain generated by bulky substituents.

Solution:

(a) For a cis-1,3-disubstituted cyclohexane, both functional groups must be on the same side of the ring plane.

(b) This requirement can be satisfied if both bonds are directed upward or both are directed downward.

(c) In a chair conformation, this corresponds to either a configuration where both are axial or both are equatorial.

(d) Equatorial positions minimize unfavorable spatial interactions with the ring scaffolding.

(e) Thus, the diequatorial (1E, 3E) conformation represents the stable thermodynamic global minimum.

Final Answer: The diequatorial (1E, 3E) conformation

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept:

The chemical reactivity of xenon hexafluoride is characterized by its tendency to undergo stepwise partial hydrolysis when exposed to limited moisture or oxide-transferring agents such as silica. These transformations proceed with the preservation or reconfiguration of the core valence shells.

Solution:

(a) When xenon hexafluoride undergoes controlled partial hydrolysis with a minimal quantity of water, it clean-cut converts into xenon oxytetrafluoride along with the liberation of hydrogen fluoride gas.

(b) An analogous transformation occurs when xenon hexafluoride is heated in a container with silicon dioxide, producing the identical liquid derivative alongside gaseous silicon tetrafluoride.

(c) The identity of the liquid compound A is thus established as xenon oxytetrafluoride, which contains a total of six valence electron pairs surrounding the central atom.

(d) To deduce the hybridization framework, the central atom forms four single bonds to fluorine, one double bond to oxygen, and retains one non-bonding lone pair.

(e) This steric demand corresponds to a total steric number of six, which mandates an sp^3d^2 hybridization scheme and produces a square pyramidal molecular geometry.

Final Answer: sp^3d^2, Square pyramidal

Answer: (A)

Go Back to Question 11

Q12.

Solution

Concept:
Synthetic elastomers are constructed through the macromolecular growth of unsaturated hydrocarbon monomers. The specific physical attributes of the resulting copolymer, such as chemical resistance and mechanical resilience, are determined directly by the structural features of its constituent monomeric units.

Solution:

(a) The synthetic rubber known commercially as Buna-N is categorized structural-wise as a highly durable copolymer designed to withstand degrative attacks from non-polar petroleum compounds.

(b) The designation of this elastomer provides a direct clue to its chemical composition, where the prefix indicates the primary diene component and the terminal letter signifies the secondary monomer.

(c) The polymerization process is initiated via a free-radical mechanism that links together a conjugated diene system with an electronically activated alkene partner.

(d) The primary unsaturated hydrocarbon employed in this formulation is 1,3-butadiene, which imparts flexibility and elastic properties to the final rubber network.

(e) The secondary structural component that delivers exceptional solvent resistance due to its polar nitrile functional group is acrylonitrile monomer.

Final Answer: Acrylonitrile

Answer: (A)

Go Back to Question 12

Q13.

Solution

Concept:
The structural configuration of a face-centered cubic lattice dictates the relative spatial positions of the constituent atoms. To establish the absolute minimum distance separating any two lattice points, one must analyze the densest packing vectors within the geometric boundary of the unit cell.

Solution:

(a) In a face-centered cubic crystal configuration, identical spherical atoms are situated at each of the eight corners and at the exact centers of the six bounding planes.

(b) The atoms positioned along the outer perimeter of the cell do not make physical contact with each other along the principal cell edge length.

(c) Instead, physical contact is maintained along the diagonal vector of any given square face of the cubic unit cell.

(d) The total length of this face diagonal can be determined using the Pythagorean theorem, which yields a value equal to the square root of two multiplied by the edge length.

(e) The closest distance of approach corresponds to exactly half of this face diagonal length, which simplifies mathematically to the cell edge divided by the square root of two.

Final Answer: $a/\sqrt{2}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 13

Q14.

Solution

Concept:
The pathway of hydrocarbon halogenation is strictly regulated by the experimental conditions. Electrophilic aromatic substitution occurs on the ring when catalyzed by a Lewis acid, whereas free-radical halogenation targets the aliphatic side-chain under photochemical or thermal activation.
Solution:

(a) The starting material with the molecular formula C_7H_8 is identified as toluene, which features an activating methyl group attached directly to a benzene core.

(b) Treatment of toluene with chlorine in the presence of an iron catalyst facilitates electrophilic ring chlorination, generating a mixture of ortho-chlorotoluene and para-chlorotoluene as compound B.

(c) When toluene is alternatively exposed to chlorine gas under conditions of intense heating and sunlight, a free-radical substitution cascade takes place exclusively at the benzylic position.

(d) Exhaustive chlorination of the benzylic carbon substitutes all three hydrogen atoms, culminating in the production of benzotrichloride as compound C.

(e) Subsequent high-temperature aqueous hydrolysis of this trichlorinated intermediate converts the functional group into a temporary triol, which dehydrates into benzoic acid.

Final Answer: o/p-Chlorotoluene and Benzotrichloride

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept:

The precise chemical structure of borax in its crystalline phase reveals that it exists as a discrete polycyclic cluster rather than a simple linear formulation. The coordination numbers and electronic geometries of the central metalloid elements vary across the internal ring structure.

Solution:

(a) The authentic anionic formula for the borax core unit is represented precisely by the molecular formulation $[B_4O_5(OH)_4]^{2-}$.

(b) The cyclic skeleton consists of a six-membered ring system containing alternating boron and oxygen atoms, bridged centrally by an additional oxygen linking group.

(c) An analysis of the individual boron centers shows that two of the atoms are bonded to three oxygen neighbors each, leaving them with an incomplete octet.

(d) These specific trivalent centers adopt a planar orientation, which corresponds structurally to an sp^2 hybridization state.

(e) The remaining two boron atoms accept an extra electron pair to bond with four oxygen atoms each, creating a tetrahedral arrangement that signifies an sp^3 hybridization state.

Final Answer: 2 and 2

Answer: (A)

Go Back to Question 15

Q16.

Solution

Concept:
In a parallel or competing kinetic scheme, a single starting material decomposes through multiple independent routes simultaneously. The total rate of reactant consumption is governed by the summation of the individual rate expressions, which influences the composite temperature dependence.

Solution:

(a) For the parallel decay of reactant K into products L and M, the individual steps operate with separate first-order rate coefficients designated as k_1 and k_2.

(b) The differential rate expression for the overall disappearance of K is written as the product of the concentration and the sum of both individual constants.

(c) Therefore, the effective net rate constant for the complete degradation process can be defined mathematically as $k = k_1 + k_2$.

(d) Differentiating this combined rate expression with respect to temperature allows the application of the classical Arrhenius equation to each constituent term.

(e) Substituting the individual energy parameters reveals that the effective overall activation energy is a weighted average determined by the expression $(k_1E_1 + k_2E_2)/(k_1 + k_2)$.

Final Answer: $(k_1E_1 + k_2E_2)/(k_1 + k_2)$

Answer: (A)

Go Back to Question 16

Q17.

Solution

Concept:

The stereochemical integrity of a chiral center during an esterification reaction depends on whether any bonds directly connected to that asymmetric carbon are broken. If the reaction takes place exclusively at a remote functional group, the absolute configuration is preserved.

Solution:

(a) The starting material is D-tartaric acid, which possesses an absolute stereochemical configuration designated as 2S,3S according to the Cahn-Ingold-Prelog priority rules.

(b) When this dicarboxylic acid is treated with a single equivalent of methanol in an acidic medium, a selective monoesterification occurs at one terminal group.

(c) The mechanism of Fischer esterification involves nucleophilic attack at the carbonyl carbon atom, leaving the tetrahedral asymmetric carbons completely untouched.

(d) Because no chemical bonds attached to carbon-2 are severed or rearranged, the relative and absolute spatial arrangement of its substituents remains identical.

(e) Consequently, the original stereochemical identity is maintained, and the configuration of the resulting monoester product at carbon-2 is strictly assigned as 2S.

Final Answer: 2S

Answer: (A)

Go Back to Question 17

Q18.

Solution

Concept:
The periodic trend for first ionization energy down a columns is normally characterized by a monotonic decrease due to increasing atomic radii. However, in the heavier elements of the boron group, structural anomalies emerge due to subshell shielding deficiencies.

Solution:

(a) Boron exhibits the highest first ionization enthalpy in its group owing to its extremely compact atomic size and tight valence shell binding.

(b) Moving from boron to aluminum, the energy decreases substantially as expected because of the addition of a principal electronic shell.

(c) When progressing to gallium, the intervention of the ten 3d transition electrons provides poor shielding, causing an unexpected contraction and a slight energy rise over aluminum.

(d) Indium follows the regular trend with a further decrease in ionization potential as the atomic radius expands significantly.

(e) Finally, thallium experiences a pronounced increase in ionization energy due to the relativistic effects and poor shielding of the fourteen 4f electrons, shifting its value above gallium.

Final Answer: $B > Tl > Ga > Al > In$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 18

Q19.

Solution

Concept:

The ecological phenomenon of eutrophication involves the dense proliferation of plant and algal biomass in aquatic ecosystems. This process is triggered when the concentration of limiting nutrient elements rises above natural baseline thresholds due to agricultural runoff or industrial waste.

Solution:

(a) Under pristine environmental conditions, the growth of primary producers in freshwater bodies is strictly regulated by the scarcity of specific inorganic nutrients.

(b) Human activities frequently introduce massive quantities of synthetic fertilizers and untreated chemical detergents directly into these fragile aquatic drainage basins.

(c) These anthropogenic effluents are heavily enriched with chemical formulations containing soluble forms of elemental phosphorus and nitrogen.

(d) The sudden abundance of these specific chemical species eliminates the natural growth restrictions, igniting an explosive proliferation of surface algal blooms.

(e) The subsequent decomposition of this massive organic matter consumes the available dissolved oxygen, leading to localized anoxia and the catastrophic collapse of the aquatic fauna.

Final Answer: Phosphates and Nitrates

Answer: (A)

Go Back to Question 19

Q20.

Solution

Concept:

Colligative properties depend solely on the total number of solute particles present in a solution. The mathematical relationship between osmotic pressure and freezing point depression can be established by linking both phenomena through the common variable of solution molality.

Solution:

(a) The osmotic pressure relation is given by the equation $\Pi = CRT$, which allows the determination of the molar concentration of the non-electrolyte solute.

(b) Substituting the values gives $4.92 = C \times 0.0821 \times 300$, which simplifies directly to yield a molarity value of exactly 0.20 moles per liter.

(c) Given that the density of the solution is assumed to be 1.0 gram per milliliter, the numerical value of molarity matches the solution molality.

(d) The formula for the lowering of the freezing point is expressed as $\Delta T_f = K_f \times m$, where m represents the molal concentration.

(e) Evaluating this expression using the provided cryoscopic constant yields $\Delta T_f = 1.86 \times 0.20$, which results in a final value of 0.372 Kelvin.

Final Answer: 0.372 K

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 20

Q21.

Solution

Concept:
The behavior of amines interacting with nitrous acid at low temperatures depends explicitly on their structural classification. Primary aliphatic amines react to form highly unstable diazonium salts that rapidly decompose to release gas, whereas primary aromatic amines produce relatively stable aromatic diazonium salts under identical parameters.

Solution:

(a) Primary aliphatic amines interact with freshly prepared nitrous acid to form highly unstable diazonium intermediates even at freezing temperatures.

(b) Benzylamine, despite containing an aromatic phenyl ring, features its amino group bound directly to an aliphatic sp3 hybridized methylene carbon center.

(c) The reaction converts the amino group into an aliphatic diazonium ion that lacks resonance stabilization from the aromatic system.

(d) This high-energy intermediate undergoes immediate spontaneous decomposition to yield nitrogen gas along with a mixture of carbocation-derived products.

(e) Consequently, benzylamine functions as the unique primary aliphatic-type amine among the given set capable of evolving gaseous nitrogen under these conditions.

Final Answer: Benzylamine

Answer: (C)

Go Back to Question 21

Q22.

Solution

Concept:
Molecular Orbital Theory utilizes linear combinations of atomic orbitals to construct molecular energy frameworks. The electronic structure and associated magnetic properties of homonuclear diatomic molecules are dictated by the sequence and occupancy of these resulting orbitals.
Solution:

(a) Nitrogen gas possesses a total of fourteen electrons, which completely fill the bonding and antibonding molecular orbitals up to the bonding pi and sigma levels.

(b) The valence configuration features a perfect pairing of all available electrons within the molecular orbitals, rendering the molecule strictly diamagnetic.

(c) The mathematical expression for bond order subtracts the antibonding electron count from the bonding electron count before dividing by two.

(d) For the nitrogen molecule, this calculation utilizes ten bonding electrons and four antibonding electrons to yield an overall bond order of three.

(e) This value represents the highest possible bond order achievable among second-period homonuclear diatomic systems while maintaining an entirely diamagnetic state.

Final Answer: N_2

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept:
The Maxwell-Boltzmann distribution model mathematically characterizes the statistical spread of molecular velocities inside a gaseous sample. The precise shape of this distribution profile undergoes a structural modification as the thermal energy of the system changes.

Solution:

(a) The most probable speed represents the exact velocity value corresponding to the peak of the Maxwell-Boltzmann distribution curve.

(b) As the absolute temperature rises, the average kinetic energy of the individual gas molecules increases proportionately.

(c) This shifting causes the peak of the speed distribution curve to translate toward higher velocity values along the horizontal coordinate axis.

(d) Because the total area under the probability curve must remain constant, the broadening of the curve forces the maximum peak height downward.

(e) Therefore, the fraction of molecules holding this shifting velocity decreases significantly, producing a shorter and broader distribution profile.

Final Answer: f_{mp} decreases, v_{mp} increases

Answer: (A)

Go Back to Question 23

Q24.

Solution

Concept:

Condensation macromolecular synthesis involves step-growth interactions linking bifunctional structural components together. This mechanism is defined by the repetitive formation of stable interunit linkages accompanied by the systematic elimination of small molecular byproducts.

Solution:

(a) Polyamides constitute a specific class of condensation polymers distinguished by the presence of recurring amide linkages within their backbone chains.

(b) Nylon-6,6 is synthesized via the chemical interaction of a six-carbon dicarboxylic acid with an equivalent six-carbon aliphatic diamine.

(c) The specific structural monomers utilized in this commercial production are adipic acid and hexamethylenediamine.

(d) The polymerization reaction couples the terminal carboxyl groups with the amine functionalities to establish strong covalent amide networks.

(e) Each successive coupling step releases a single molecule of water as a byproduct, satisfying the criteria for condensation-type transformations.

Final Answer: Nylon-6,6

Answer: (A)

Go Back to Question 24

Q25.

Solution

Concept:
The Reimer-Tiemann transformation alters the structural profile of phenol compounds to yield ortho-formylated derivatives. The pathway relies on the initial generation of a highly reactive, neutral electron-deficient carbon species under strongly alkaline parameter conditions.

Solution:

(a) The addition of concentrated sodium hydroxide to chloroform induces an initial deprotonation step to generate a trichloromethyl carbanion intermediate.

(b) This carbanion spontaneously undergoes alpha-elimination, expelling a chloride anion to form a neutral divalent carbon species.

(c) The resulting intermediate is dichlorocarbene, which possesses an empty p-orbital that renders it highly electrophilic in nature.

(d) The electron-rich phenoxide ring subsequently undergoes nucleophilic attack directed at this electrophilic carbene center at the ortho position.

(e) Subsequent basic hydrolysis and acidification steps complete the formylation process, finalizing the conversion of phenol into the salicylaldehyde product.

Final Answer: Carbene

Answer: (D)

Go Back to Question 25

Q26.

Solution

Concept:
The reducing capability of phosphorus oxoacids is fundamentally determined by the presence of direct, non-hydrolyzable phosphorus-hydrogen bonds. The overall molecular architecture must simultaneously accommodate catenated structural frameworks to exhibit distinct localized linkages.

Solution:

(a) Pyrophosphorous acid, possesses the precise empirical molecular formula designated as $H_4P_2O_5$.

(b) Structural analysis of this oxoacid reveals a central asymmetric core containing a direct phosphorus-phosphorus single bond link.

(c) The coordination environment of the first phosphorus atom features two hydroxyl groups and one terminal oxo partner.

(d) The second catenated phosphorus atom is bound to a single hydroxyl group, one oxo group, and two directly appended hydrogen atoms.

(e) These localized phosphorus-hydrogen linkages act as highly active hydride sources, providing the molecule with its characteristically powerful reducing properties.

Final Answer: Pyrophosphorous acid ($H_4P_2O_5$)

Answer: (C)

Go Back to Question 26

Q27.

Solution

Concept:
Zero-order reaction kinetics are defined by a transformation rate that remains entirely independent of changes in reactant concentration. The mathematical expression relating half-life to the initial parameters reflects this linear relationship directly.

Solution:

(a) The integrated rate equation governing zero-order chemical kinetics is expressed linearly as $[A] = [A]_0 - kt$.

(b) The definition of half-life specifies the precise time interval required for the reactant concentration to decay to exactly half its initial value.

(c) Substituting this boundary condition into the integrated equation yields the specific half-life expression: $t_{1/2} = [A]_0/(2k)$.

(d) Inserting the given initial parameters into this framework gives $t_{1/2} = 0.20/(2\times4.0\times10^{-3})$.

(e) Simplifying this numerical fraction results in an absolute time duration of exactly 25 seconds for the half-life period.

Final Answer: 25 s

Answer: (A)

Go Back to Question 27

Q28.

Solution

Concept:

The Williamson ether synthesis operates via a classical bimolecular nucleophilic substitution pathway. To achieve optimal synthetic efficiency and avoid competing elimination pathways, the steric profile of the reacting partners must be carefully optimized.

Solution:

(a) The substitution mechanism demands a backside nucleophilic attack by an alkoxide ion directed at a vulnerable carbon-halogen center.

(b) If a tertiary alkyl halide is exposed to a strong alkoxide base, steric congestion blocks the substitution pathway entirely.

(c) Instead, the basic alkoxide induces a dominant E2 elimination reaction, generating an alkene byproduct rather than the desired ether.

(d) To synthesize tert-butyl methyl ether efficiently, the unhindered methyl group must serve as the primary electrophilic substitution target.

(e) Combining a sterically unhindered methyl halide with a bulky sodium tert-butoxide nucleophile maximizes substitution pathways while suppressing elimination.

Final Answer: Sodium tert-butoxide and Methyl bromide

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 28

Q29.

Solution

Concept:
The acid-base behavior of main-group element oxides demonstrates a regular periodic transition moving down a vertical column. This variation is driven by changes in atomic radius, electronegativity, and the metallic character of the central element.

Solution:

(a) Elements situated at the apex of group 15 exhibit non-metallic character, which translates to the formation of strongly covalent, acidic oxides.

(b) Dinitrogen trioxide features highly electronegative nitrogen centers that polarize bonds extensively, rendering the oxide completely acidic.

(c) Moving down the column to arsenic and antimony, the metallic character rises, shifting their respective trioxides into amphoteric domains.

(d) Bismuth sits near the bottom of the group and exhibits pronounced metallic behavior, rendering its oxide purely basic.

(e) Thus, dinitrogen trioxide remains the unique member of this series that behaves in an exclusively acidic manner.

Final Answer: N_2O_3

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 29

Q30.

Solution

Concept:
The common-ion effect dramatically suppresses the dissociation equilibrium of a sparingly soluble salt. The final concentration of the shared ionic species is determined primarily by the complete dissolution of the added strong electrolyte.

Solution:

(a) The sparingly soluble salt dissociates according to the equilibrium expression $MX_2 \rightleftharpoons M^{2+} + 2X^-$.

(b) Let the molar solubility of the salt in this modified chemical environment be designated as S.

(c) The equilibrium concentration of the metal cation is equal to S, while the total common anion concentration equals $2S + 0.01$.

(d) Because the solubility product constant is small, the contribution from the sparingly soluble salt can be neglected, simplifying the anion concentration to 0.01 M.

(e) Substituting these values into the solubility expression gives $4.0 \times 10^{-12} = S \times (0.01)^2$, which yields a solubility value of 4.0×10^{-8} M.

Final Answer: 4.0×10^{-8} M

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 30

Q31.

Solution

Concept:
The reactivity of carboxylic acid derivatives toward nucleophilic acyl substitution depends on the leaving group ability. A better leaving group stabilizes the negative charge more effectively after departure, which correlates with a weaker conjugate base, thereby accelerating nucleophilic attack.

Solution:

(a) Nucleophilic acyl substitution reactions proceed via a tetrahedral intermediate followed by the expulsion of a leaving group.

(b) In acetyl chloride, the leaving group is the chloride ion, which is a weak conjugate base of a strong acid, making it an excellent leaving group.

(c) In acetic anhydride, the acetate leaving group is stabilized by resonance, rendering it moderately good but less reactive than chloride.

(d) In ethyl acetate, the ethoxide leaving group is a strong base with poor leaving capability, lowering the overall reaction rate significantly.

(e) In acetamide, the amide ion is an exceptionally strong base and a terrible leaving group, making it the least reactive derivative.

Final Answer: I > III > II > IV

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 31

Q32.

Solution

Concept:

The geometry of interhalogen ions can be accurately predicted using Valence Shell Electron Pair Repulsion theory. Determining the total steric number of the central element reveals the basic spatial orientation of both bonding pairs and lone electron pairs.

Solution:

(a) The triiodide ion consists of a central iodine atom bonded to two surrounding outer iodine atoms while bearing a net negative charge.

(b) The central iodine atom possesses seven original valence electrons plus one additional electron from the negative charge, totaling eight valence electrons.

(c) Two of these eight valence electrons are utilized to establish single covalent sigma bonds with the two terminal iodine atoms.

(d) The remaining six non-bonding electrons organize into three discrete lone pairs residing on the central iodine atom.

(e) This combination yields a total steric number of five, directing a linear molecular geometry where the three lone pairs occupy equatorial positions.

Final Answer: Linear, 3 lone pairs

Answer: (A)

Go Back to Question 32

Q33.

Solution

Concept:

An adiabatic thermodynamic process operates with zero net thermal energy transfer between a system and its surroundings. Combining the first law of thermodynamics with the ideal gas equation yields specific mathematical expressions relating state variables during expansion.

Solution:

(a) For an ideal gas undergoing a reversible transformation, the infinitesimal work done equals the negative change in internal thermal energy.

(b) Expressing the internal energy change through heat capacity and substituting pressure from the ideal gas law leads to a differential relation.

(c) Integrating this differential equation between the initial and final states introduces the specific heat capacity ratio gamma.

(d) The mathematical integration establishes a constant product between the absolute temperature and the volume raised to the power of gamma minus one.

(e) This derived relational formula strictly governs the behavior of temperature and volume coordinates during any reversible adiabatic expansion.

Final Answer: $TV^{\gamma-1}$ = Constant

Answer: (A)

Go Back to Question 33

Q34.

Solution

Concept:

The structural architecture of deoxyribonucleic acid is defined by specific biochemical parameters established in the double-helix model. The polymer structural stability depends on a precise arrangement of nucleotide components, sugars, and complementary base pairs.

Solution:

(a) The macro-structural backbone of a DNA strand consists of alternating repeating units of deoxyribose sugar and hydrophilic phosphate groups.

(b) The two individual polynucleotide strands are aligned anti-parallel to one another, running in opposite 5' to 3' directions.

(c) Complementary nitrogenous bases point inward, with adenine forming exactly two hydrogen bonds with thymine to stabilize the internal core.

(d) The carbohydrate component integrated into the structural chain is specifically classified as a D-form 2-deoxyribose sugar molecule.

(e) Thus, the statement describing the alternating sugar-phosphate backbone represents a completely accurate architectural feature of the molecule.

Final Answer: The backbone is made up of alternating sugar and phosphate units.

Answer: (C)

Go Back to Question 34

Q35.

Solution

Concept:

Vigorous oxidation of alkylbenzenes using strong oxidizing agents targets the benzylic carbon center. Regardless of the length of the aliphatic side chain, complete oxidation breaks down the alkyl segment to yield a simplified aromatic carboxylic acid.

Solution:

(a) Ethylbenzene features an aliphatic side chain attached to an aromatic ring, with the adjacent carbon categorized as a benzylic position.

(b) The presence of benzylic hydrogen atoms is mandatory for initiating the oxidative degradation path driven by potassium permanganate.

(c) Heating with hot alkaline permanganate induces a robust cleavage of the carbon-carbon sigma bond within the ethyl side chain.

(d) The benzylic carbon is oxidized completely to a carboxylic acid salt, while the terminal methyl group is lost as carbon dioxide.

(e) Subsequent treatment with hydronium ions protonates the intermediate benzoate salt, isolating benzoic acid as the major organic product.

Final Answer: Benzoic acid

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 35

Q36.

Solution

Concept:

The hydrometallurgical extraction of noble metals relies on selective complexation followed by a chemical reduction step. A more reactive metal can displace a less reactive metal from its soluble coordination complex based on standard reduction potentials.

Solution:

(a) Initial leaching of the raw ore with sodium cyanide solution in the presence of oxygen dissolves the noble metals as cyanometallate complexes.

(b) The resulting soluble complex holds the target metal ion in a stable coordination environment with cyanido ligands.

(c) To recover the elemental metal, a reducing agent with a significantly lower reduction potential must be added to the aqueous mixture.

(d) Zinc dust is introduced because zinc is highly electropositive and displaces the silver or gold ions from solution.

(e) Zinc undergoes oxidation to form a stable tetracyanidozincate complex, forcing the noble metal ions to reduce into pure metallic precipitates.

Final Answer: Zinc dust

Answer: (A)

Go Back to Question 36

Q37.

Solution

Concept:

The Freundlich adsorption isotherm provides an empirical relationship modeling how the quantity of gas molecules bound to a solid surface changes with equilibrium pressure. The mathematical parameters reflect different adsorption behaviors under changing pressures.

Solution:

(a) The empirical equation is formulated as the mass of adsorbate per unit mass of adsorbent proportional to pressure raised to the power of one over n.

(b) The exponent parameter represents a mathematical indicator of the overall intensity and energetic favorability of the adsorption process.

(c) At exceptionally low pressures, adsorption is directly proportional to pressure, causing the value of one over n to approach unity.

(d) At high pressures, the surface reaches saturation, making adsorption independent of pressure, which drives the value of one over n toward zero.

(e) Under normal conditions, the value varies continuously between these boundary limits, remaining strictly bounded between zero and one.

Final Answer: Between 0 and 1

Answer: (A)

Go Back to Question 37

Q38.

Solution

Concept:

Distinguishing between primary and secondary amine groups requires an organic test that responds selectively to differences in nitrogen substitution. Specific nucleophilic transformations can only proceed if the nitrogen atom retains a minimum number of protons.

Solution:

(a) The carbylamine reaction is a diagnostic test specific to primary amines, operating for both aliphatic and aromatic varieties.

(b) The process involves heating the amine sample with a mixture of chloroform and an ethanolic solution of potassium hydroxide.

(c) The reaction proceeds through a dichlorocarbene intermediate, which undergoes nucleophilic attack by the primary nitrogen center.

(d) Because the primary amine possesses two protons, it can undergo double dehydration to produce an intensely foul-smelling isocyanide product.

Final Answer: Carbylamine test

Answer: (A)

Go Back to Question 38

Q39.

Solution

Concept:

The thermal stability of main-group hydrides depends on the strength of the covalent bond formed between the central atom and hydrogen. Bond strength is determined by orbital overlap, which correlates with the atomic size of the element.

Solution:

(a) Moving vertically down group 16, the atomic radius of the central chalcogen atom increases continuously from oxygen to tellurium.

(b) This progressive increase in size causes the valence orbitals to become more diffuse, resulting in less efficient spatial overlap with hydrogen 1s orbitals.

(c) Consequently, the localized bond dissociation energy of the chalcogen-hydrogen bond decreases dramatically down the column.

(d) A weaker bond means less thermal energy is required to cleave the linkage, reducing its resistance to thermal decomposition.

(e) Therefore, hydrogen telluride has the lowest thermal stability, while water exhibits the highest stability within the group.

Final Answer: $H_2Te < H_2Se < H_2S < H_2O$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 39

Q40.

Solution

Concept:
Arrhenius's theory of electrolytic dissociation relates the electrical conductance of a weak electrolyte solution to its fractional ionization. The degree of dissociation can be determined by comparing its observed conductance with its conductance at infinite dilution.
Solution:

(a) The degree of dissociation of a weak electrolyte is calculated as the ratio of equivalent conductance at a given concentration to that at infinite dilution.

(b) This mathematical relationship is represented by the formula alpha equals the equivalent conductance divided by the limiting equivalent conductance.

(c) Substituting the provided parameters into this expression yields the fraction: alpha equals eight divided by four hundred.

(d) Reducing this numerical fraction simplifies the expression to two divided by one hundred, which corresponds to a value of 0.02.

(e) This decimal value represents the precise degree of dissociation for the weak electrolyte at the specified molar concentration.

Final Answer: 0.02

Answer: (A)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	B	3	B	4	B	5	B
6	B	7	A	8	A	9	B	10	A
11	A	12	A	13	B	14	B	15	A
16	A	17	A	18	B	19	A	20	A
21	C	22	B	23	A	24	A	25	D
26	C	27	A	28	A	29	A	30	A
31	A	32	A	33	A	34	C	35	A
36	A	37	A	38	A	39	A	40	A